

nature, and consist of a series of beds and lenses of pure sulphur at a depth of several hundred feet from the surface.

The discovery of the occurrence of sulphur of this type was made so far back as 1865, in connection with a well drilled for oil. All attempts at mining the sulphur failed, however, until some fifteen years ago, when a highly ingenious method was devised for winning this substance without recourse to the ordinary costly underground operations usually prosecuted in mining. This process makes use of the fact that sulphur melts at a relatively low temperature. By drilling a well through the overlying rock until the sulphur bed is tapped, and then sinking a series of interpenetrating pipes through which superheated steam is forced, the sulphur is melted and forced to the surface as a hot liquid, where it is piped to large bins, into which it pours and cools. This process, which is known as the Frasch process after its inventor, has been described as one of the triumphs of modern technology, and its successful application to the Gulf Coast deposits has in the past fifteen years transferred the centre of the world's sulphur industry from the island of Sicily to the United States, making the States absolutely independent of the rest of the world in this important particular.

With the development of the world-war, the sulphur deposits of the Gulf regions have, of course, assumed special importance as supplying the sulphur needed in the manufacture of gunpowder and other explosives. But in addition to this, these deposits have quite unexpectedly during the past few months been able to meet and solve a critical resource problem arising out of the submarine campaign. This problem concerned the raw materials of the large and very vital sulphuric acid industry, and arose from the fact that most of the several million tons of sulphuric acid used in the United States was made from sulphur-bearing minerals called pyrites, brought as ballast in quantity from large deposits in Spain. The restricted shipping conditions resulting from recent events as a matter of course seriously affected this source of supply, and since sulphuric acid is a product nearly as fundamental to industry as iron or coal, the situation bade fair to assume critical proportions. But it so happens that crude sulphur can also be used in making sulphuric acid, and accordingly the Gulf sulphur deposits have come forward to tide over the dearth of Spanish pyrites until the domestic supplies of pyrites, which are adequate, but as yet only in part developed, can be brought up to a suitable measure of productiveness.

There are numerous lean deposits of sulphur in many of the Western States, but these as yet have practically no effect upon the output of the country. It is certain, therefore, that without the Gulf deposits and the ingenious method of making them available, the United States would have scarcely been able to meet successfully the war needs of sulphur and sulphuric acid, which goes to show, of course, the pressing necessity for widespread appreciation and understanding of the importance of proper development of the mineral industries of the nation.

SCIENCE AS A VEHICLE OF EDUCATION.¹

THE tendency of the modern school of political thought is to attribute the majority of the great historical events which have attended the various phases of human development to the operation of unseen underlying economic forces. The recognition of this fundamental truth represents a noteworthy

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advance towards the completer understanding of the factors underlying and determining the evolution of man and of human institutions, but, admitted that economic forces wholly or very largely determine the political evolution of mankind, the question still remains: To what in turn are we to attribute the incessant fluctuations of the ever-urging economic forces? It is not that one consistent economic pressure, incident everywhere and operating in a definite direction, has continually urged mankind towards some undeviating goal; quite the contrary—the economic pressure upon mankind has been fluctuating, variable both in incidence and in direction, and not always advantageous in its immediate outcome.

Not infrequently attempts have been made to correlate these economic forces with geographical conditions, with the happy or unhappy conjunction, here or there, of river, plain, and sea. But the ever-changing aspects of political geography are not to be interpreted so easily. In relation to the brief life of man, the geographic contour of the earth is well-nigh eternal and immutable. Setting aside, without underrating their possible importance, the very few historical instances of decisive variation in geography and climate, such as the desiccation of Central Asia and the extraordinarily rapid shrinkage of at least one great inland sea, Lake Tchad, it is evident that in the long run, were geographical contour and climate the sole factors underlying and determining the incidence of economic forces, the political geography of the world would ere this have become as static as its physical geography, of which it would be the inevitable and deducible outcome. The ceaseless ferment of international politics, never more turbulent than now, would then remain utterly inexplicable.

To find any analogy corresponding with the bewildering intricacy and rapid fluctuations of political history and geography, we must turn to the inward workings of the human mind, of which economic forces are in ultimate analysis merely the outcome and expression, deviated or constrained, but not created by the geographical, climatic, or biological environment in which they find their outlet. Behind the economic forces which have fashioned human destiny we must seek again the more potent forces of human energy, curiosity, and inventiveness.

It is related that when recently the untutored savages of a certain region of East Africa first saw an aeroplane hovering over their heads they worshipped it as a god, or the expression of a god-like power. A group of high-school or university students would have regarded that same aeroplane with mild curiosity or supercilious indifference, so greatly has education, or what passes for education, blinded our eyes to underlying verities, to truths which are patent to the savage! For, if we regard it aright, every automobile, every passing electric street-car, every ray of light we cast into the darkness with the touch of a finger, is a miracle and a monument to the creative intellect of man.

It is these things and such as these that determine the economic forces which fashion the history of man. The discovery of America was not an accident; it was the outcome of measurement and invention, directed by an inspired curiosity regarding the structure of the universe. The discovery of the steam-engine was not an accident; it was the outcome of countless patient investigations inspired by no thought of ulterior gain. Electricity was not harnessed by financiers, but by the monumental intellectual labours of Oersted, Ampère, and Faraday. These things did not happen by chance; they did not, like Athena, spring full-armed from the brain of Zeus; they did not rain down upon earth from heaven, nor have they always been. They were not fashioned in the market-place, nor yet achieved

by sporadic flashes of prophetic inspiration. They are the expressions of the creative intellect of man operating under a certain discipline of thought, inspired by the one undeviating desire to understand, and by understanding to control, the environment in which we have our being.

Essentially the same discipline of thought and essentially analogous expansions of economic opportunity have been operative and determinative forces at all stages of man's development. The foreshortening of our remote past, due to its relatively immense distance from our own lives and the accelerated evolution of our own day, tends to render us forgetful of the obscure struggles and achievements of our ancestors. Yet the peoples from whom we sprang did not lack their Faradays or Pasteurs, upon whose accumulated labours they fashioned new civilisations and rose to greater and ever greater mastery over the inanimate, brute forces to which our yet remoter forbears paid the homage inspired by fear. This is the primary impelling force which fashions the fluctuating yet ever-progressing evolution of man, the force of creative human intellect, perchance inspired, yet inspired not without preparatory labour, for, in the words of Pasteur, "Chance favours only the prepared mind."

If the woof of the fabric of history is economic, the warp is supplied by the creative curiosity of man, operating under the discipline of thought which we now call "scientific," and culminating in discoveries and inventions.

It is strange how little suspicion of these facts enters into the minds of the typical products of modern scientific pedagogy, the vast number of students who in our day patiently submit themselves for years to the exacting discipline of scientific training in order that they may apply it hereafter to the solution of the immediate practical or theoretical problems of their time. The more prolonged and extensive their training, the more intensely specialised their interests become, until the material and spiritual welfare of the vast human family, which alone confers meaning and dignity upon their task, becomes a matter of utter indifference in comparison with the identification of a diatom or the measurement of the angle of a crystal.

There can be little question that as pedagogues and expositors, with a few brilliant exceptions, scientific scholars and investigators have failed, and that in a manner and to a degree most disastrous to the welfare of their chosen field of intellectual endeavour. Notwithstanding several decades of widespread training in scientific method and the scientific discipline of thought, and notwithstanding, also, the multitude of technically skilled and professionally trained men who have issued from our laboratories, there is as yet little or no sympathy or understanding displayed by the public, or even by our own pupils, with the larger problems and broader aspects of science. The reason is not far to seek; deficient sympathy and insight have propagated their like, and we are merely reaping that which we have sown. We have taught our pupils to regard science as an arid, inhuman outgrowth of pure intellectualism, useful perchance, but not endearing, interesting perchance as chess is interesting, but never touching the deeper problems and broader aspirations of mankind save to wither our illusions and proffer the material bait of utility in their stead. Our discipline of thought has taught us to shun hasty generalisation, but we have taught our pupils never to generalise at all, and in teaching them to contemplate and to conquer the difficulties that lie at hand we have deprived them of the exalted vision of the ultimate goals towards which our labours are directed. Thus have we earned, and most richly deserved, the indifference or the veritable hostility of the public, and, crowning absurdity of all, the sciences are everywhere proclaimed antagonistic to the "humanities."

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How gross is the caricature of our ideals and our functions which we have implanted in the minds of our contemporaries may be gathered from the words of the great founders of the scientific school of thought. Witness the exalted vision of their labours embodied in the utterances of three great physicists, representatives of three distinct epochs of scientific thought: "I do not know what I may appear to the world," said Newton, "but to myself I seem to have been only like a boy playing on the seashore, and diverting myself now and then in finding a smoother pebble or a prettier shell than ordinary, while the great ocean of truth lay all undiscovered before me." "The laws of Nature," said Oersted, "are the thoughts of God," or, in the words of a master of our own day, J. J. Thomson: "As we conquer peak after peak, we see in front of us regions full of interest and beauty, but we do not see our goal, we do not see the horizon; in the distance tower still higher peaks, which will yield to those who ascend them still wider prospects, and deepen the feeling, the truth of which is emphasised by every advance in science, that 'Great are the works of the Lord.'" Or, in regard to the function of science towards the welfare of humanity, compare the prophetic utterances of Harvey: "We can never want matter for new experiments. We are as yet got little further than to the surface of things: we must be content, in this our infant state of knowledge, while we know in part only, to imitate children, who, for want of better skill and abilities and of more proper materials, amuse themselves with slight buildings. The further advances we make in the knowledge of Nature the more probable and the nearer to truth will our conjectures approach; so that succeeding generations, who shall have the benefit and advantage both of their own observations and those of preceding generations, may then make considerable advances, 'when many shall run to and fro and knowledge shall be increased,'" with the words of Pasteur, written two hundred and fifty years later: "Science is in our age the soul of the prosperity of nations and the living source of all progress. Without doubt the politician with his tedious and perpetual discussions seems to be our guide. Vain illusion! That which leads us is scientific discovery and its applications." And yet the material welfare of man is not the chief justification of science, for, in the words of the same master: "The cultivation of the sciences in their highest expression is perhaps more necessary to the moral welfare of a nation than to its material prosperity."

In these utterances we read, not the cheap hope of material gain or the paltry personal triumph of the clever solver of an intricate intellectual puzzle, but a sense of "something far more deeply interfused," an expression of the awe and abiding wonder which the contemplation of our universe compels, and a deep conviction of the vast underlying import of natural law in the welfare and aspirations of mankind. Why, then, do we so diligently wrap up these aspirations and convictions in formulæ and conceal them under the cloak of a pedantic affectation of hypercritical exactitude? There is a grandeur in science, wide as the universe itself. There is a human import of science, embracing the material and social welfare of the totality of mankind. Would it not, then, be well to convey some suspicion of these facts to our pupils?

We have succeeded after many years of conflict with educational authorities in introducing scientific studies into the curriculum of schools, but what have we accomplished thereby? Through the agency of the compulsory dissection of flowers, the unalleviated algebra of statics, or the uncertain pursuit of the elusive elements of a chemical "unknown," we have given rise to a rooted aversion to science in the minds of many and have attracted a few to the pursuit of science for the sake of material gain, but in how many minds

have we implanted the idea of the intrinsic grandeur or the essential ultimate value of their scientific studies? The spectre of specialism has pursued us. "Science" must be chemistry, physics, geology, botany—anything rather than the study of the dependency of human welfare upon our capacity to control our environment, and the contemplation of the majestic spectacle of the order of Nature gradually unfolding itself to man's consciousness and placing in his hand the implements of ever-augmenting power to control his destinies and attain that ultimate comprehension of the universe which has in all ages constituted the supreme aspiration of man. Had we offered this, had we employed scientific education rather than scientific training as the introductory chapter of the book of scientific knowledge, then all the educated civilised inhabitants of the world to-day would look to science for hope and inspiration, and we should hear no more of the conflict between science and the "humanities," for science would be recognised in its true light, as the first and greatest of the "humanities."

In the universities, even more than in the schools, specialisation has sacrificed education to the exigencies of training. Every opportunity is offered to the student of becoming an expert in the technique and a master of the details of any of the sciences, but on their relationship to the larger needs and aspirations of the world our instructors are silent. This silence arises only too often out of indifference, but where indifference does not prevail then an over-sensitive deference to professional etiquette no less effectually imposes silence upon the professional teacher of science. The desire not to trespass upon the technical field of a colleague and the desire to avoid the criticism of colleagues which may be aroused by the appearance of over-generalisation inhibit in almost every instance any deliberate attempt to open up before the student the deeper foundations and wider implications of the scientific discipline of thought.

As the demands for "vocational training" become more insistent and more complex, this condition becomes more and more aggravated, so that unless measures be deliberately taken to check the prevailing tendencies we may anticipate, alongside the continual improvement of technical training, the progressive deterioration of scientific education, with accompanying decay of scientific philosophy and increasing misunderstanding of the purposes and misapplication of the products of scientific investigation.

Much may be done by the individual teacher; still more might be accomplished by a deliberate campaign of popularisation, by taking the public into our confidence regarding our wider aims and the part played by investigation and discovery in the life and destiny of man. But there is one desirable measure which should be taken by the universities as the official leaders of educational reform, namely, the recognition of the study of the historical development of science in its relationship to human welfare and the evolution of human institutions, as a legitimate department of the many-sided curriculum which the modern universities offer to the student-public. It will be admitted, I think, that scientific investigation, discovery, and invention have played at least as great a part as war, literature, or commerce in the evolution of civilisation, and, that being the case, it is nothing less than astounding that while ample facilities are offered by our universities to the student of the history of war, literature, or commerce, no facilities and no academic recognition whatever are offered to the student of the history of science.

It is perhaps a debatable question whether this end could best be attained by the foundation of a new department and a separate chair or lectureship in the history of science, or whether the situation could prefer-

ably be met by the co-ordinated effort of existing departments. However this may be, one thing is certain, that the present atomistic condition of scientific learning in the minds of our students and the restricted utilitarianism of their outlook will not be corrected by offering them a "course in general science," consisting of a *mélange* of ill-assorted fragments of scientific specialities and necessarily failing to furnish either a vehicle of training or a vehicle of education; nor will it be corrected by offering them courses in another specialised course in the history of science in which that history is violently detached from the history of the development of man and of the evolution of his institutions, from the study of the part played by knowledge in determining the reaction of the mind of man to the varying circumstances by which from epoch to epoch he has successively found himself envired; for the new course must above all things be one of the "humanities."

UNIVERSITY AND EDUCATIONAL INTELLIGENCE.

MANCHESTER.—A group of large firms engaged in the principal industries of the Manchester district has offered to the governing body of the School of Technology the sum of 3000l., spread over a period of five years, towards the cost of establishing a new department of industrial management. The Manchester Education Committee has recommended that this gift be accepted and expressed its high appreciation of the donors' public spirit. It is proposed that a lecturer shall be appointed for this period of five years at a salary of 600l., to conduct research in the subject of industrial management, to organise a new department, to lecture to members of the University and to the public, and to assist industrial concerns in the solution of management problems. To make doubly sure that the department shall keep in close touch with practice, a number of managers, directors, scientific experts, and others who have had special experience or are responsible for important innovations, will be invited to deliver public lectures, for which they are being offered substantial fees. These lectures should be of assistance not only to future managers, but also to those already in that position; they will strengthen the idea that management is a science, and that every manager is, or should be, something of a scientific researcher.

SHEFFIELD.—It was something more than a domestic function at which the Marquis of Crewe was installed as Chancellor of the University on Friday, February 15. The ceremony was the first of its kind in Sheffield, as the late Chancellor was born, so to speak, with the University. He was part of the gift of the Crown, whereas Lord Crewe was elected by the Court in the manner prescribed by the charter. The formal act of installation was conceived as taking place at a meeting of the Court in the presence of the University, and the Senior Pro-Chancellor (Mr. H. K. Stephenson), who normally presides over the Court, performed the act of installation. This was a departure from the precedents of Leeds and Manchester, but the Sheffield interpretation of the meaning of the ceremony is probably based on sounder legal grounds. Once in the chair, the new Chancellor took charge of the proceedings with characteristic grace and dignity. Before declaring the Congregation open for the conferment of degrees, he spoke admirably on various burning problems, and his pronouncements should do much to increase the intimacy and friendliness of the relations between the civic and industrial life of the city—close as they already are. It was something to hear the first chairman of the Privy Council Committee on Scientific and Industrial Research say that in his view